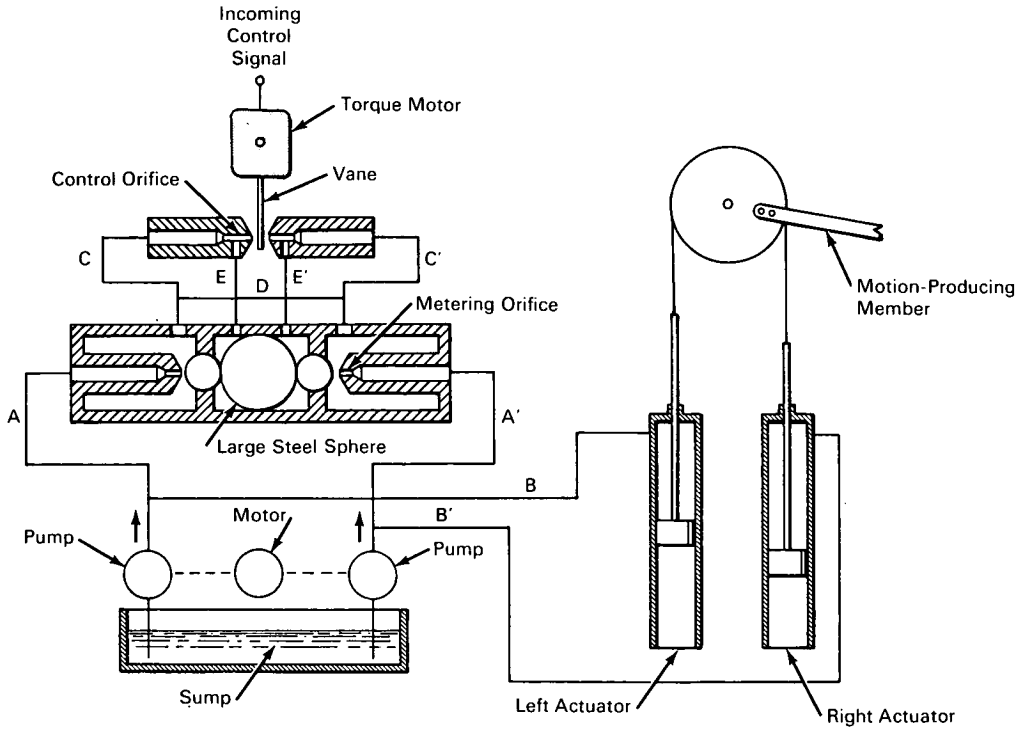
AEC-NASA TECH BRIEF

Quick-Response Servo Amplifies Small Hydraulic Pressure Differences



The problem:

To develop a hydraulic servo which controls the flow rates and pressures within a hydraulic system so that the output force of the servo system is independent of the velocity of the mechanism which the system actuates. The servo must be capable of operating with dirty or impure fluids without sticking or jamming. Hydraulic servos which use flow-responsive valves, variable flow pumps, or high inertia mechanical members, are too slow or require too large a signal force.

The solution:

A hydraulic servo, operating within a continuous-flow hydraulic system, which quickly diverts fluid to either of two actuators. Small pressure differences induced in the system by a low-power signal device are sensed by the servo and amplified through the

(continued overleaf)

action of a low inertia ball valve arrangement. Constant total system flow rate is maintained throughout the controlling function.

How it's done:

The servo is a tandem arrangement comprising two constant speed pumps, two metering orifices, and two control orifices. Between the two metering orifices is a chamber containing a large steel sphere. Partitions on either side of the chamber contain a small steel sphere in proximity to each metering orifice and in contact with the large sphere. A vane or fin, connected to a low power torque motor, is suspended midway between the two control orifices.

Each pump delivers fluid to one metering orifice through lines A and A', as shown in the diagram. The fluid exiting from each of these orifices impinges on the adjacent small steel sphere, exits through a port, and enters the corresponding control orifice through lines C and C'. Line D is connected across lines C and C' so that each control orifice experiences an identical incoming pressure. Fluid exiting from each control orifice strikes the vane and returns to the sump. Lines E and E' extend from within each control orifice to either side of the chamber housing the large sphere so that each half of the chamber experiences the pressure within its respective control orifice. Hydraulic lines A and A' also serve lines B and B' which lead to one of two hydraulic actuators.

The purpose of the servo is to divert fluid to either of the two actuators when the vane swings toward one of the two control orifices. When the vane is midway between the orifices, no fluid flows to the actuators, and the system is in neutral operation. When a low power signal is delivered to the torque motor, the vane swings in the proper direction, for example, toward the left control orifice. Fluid exiting from this orifice is restricted by the vane so that its velocity decreases below that of the right orifice and the pressure within the left orifice rises above that of the right orifice. The line (E) leading from the left orifice to the left side of the large sphere chamber transmits this increased pressure to the left side of the sphere.

This sphere, with a pressure differential existing between its two sides, moves to the right, pushing the right small sphere ahead of it. The left sphere follows the large sphere since the pressure to its right, although increased, is still less than the pressure of the fluid exiting from the left metering orifice. The spheres displace to the right until the pressure in the right metering orifice rises sufficiently through the restricting action of the right sphere to match the force displacing the spheres. The shifting of the spheres causes an increased fluid flow through the left metering orifice, and a decreased fluid flow through the right orifice. Therefore, a portion of the fluid exiting from the right-hand pump through A' now diverts to the right-hand actuator through Line B'. Fluid flows from the left actuator to the left orifice through Line B to increase the flow through this orifice. The two actuators thus operate in a complementary fashion through the action of the low inertia spheres.

Notes:

1. This servo is a dynamic feedback control deivce. The combination of the valve and actuator provides a force output. That is, for a given electrical input, a specific output force is developed that is essentially independent of load velocity. In certain classes of servos, such as force reflecting master-slave manipulators, this force control characteristic is greatly desired above the velocity control characteristic of the usual flow control valve.
2. Since the metering action is accomplished without change in flow rate from the pumps, and since the mass of the three steel balls is low, the servo responds quickly to vane deflection signals.
3. The continuous flow feature of the valve provides a self-cleaning action and ensures smooth, stick free operation without the need of externally applied vibration (dither), even with the use of dirty or impure fluids.
4. Additional information concerning this innovation is contained in patent #3,031,846, available from U.S. Patent Office.
5. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 S. Cass Avenue
   Argonne, Illinois 60439
   Reference: B66-10498

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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